Configure Segment Routing for IS-IS Protocol


This module provides the configuration information used to enable segment routing for IS-IS.

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Enabling Segment Routing for IS-IS Protocol

Segment routing on the IS-IS control plane supports the following:

- IPv4 and IPv6 control plane
- Level 1, level 2, and multi-level routing
- Prefix SIDs for host prefixes on loopback interfaces
- Multiple IS-IS instances on the same loopback interface for domain border nodes
- Adjacency SIDs for adjacencies
- MPLS penultimate hop popping (PHP) and explicit-null signaling

This task explains how to enable segment routing for IS-IS.
Before You Begin

Your network must support the MPLS Cisco IOS XR software feature before you enable segment routing for IS-IS on your router.

Note
You must enter the commands in the following task list on every IS-IS router in the traffic-engineered portion of your network.

SUMMARY STEPS

1. configure
2. router isis instance-id
3. address-family \{ ipv4 | ipv6 \} [ unicast ]
4. metric-style wide [ level \{ 1 | 2 \}]
5. mpls traffic-eng level
6. mpls traffic-eng router-id interface
7. segment-routing mpls
8. exit
9. mpls traffic-eng
10. commit

DETAILED STEPS

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> configure</td>
<td></td>
</tr>
</tbody>
</table>
| **Step 2** router isis instance-id | Enables IS-IS routing for the specified routing instance, and places the router in router configuration mode.  
**Example:**
RP/0/RSP0/CPU0:router(config)# router isis instance-id |
| **Step 3** address-family \{ ipv4 | ipv6 \} [ unicast ] | Specifies the IPv4 or IPv6 address family, and enters router address family configuration mode.  
**Example:**
RP/0/RSP0/CPU0:router(config-router)# address-family ipv4 unicast |
| **Step 4** metric-style wide [ level \{ 1 | 2 \} ] | Configures a router to generate and accept only wide link metrics in the Level 1 area.  
**Example:**
RP/0/RSP0/CPU0:router(config-router)# metric-style wide level 1 |
<table>
<thead>
<tr>
<th>Step</th>
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<th>Purpose</th>
</tr>
</thead>
</table>
| 5    | `mpls traffic-eng level` | Enables IGP traffic engineering functionality. Example: 
|      | `RP/0/RSP0/CPU0:router(config-isis-af)# mpls traffic-eng level-2-only` | |
| 6    | `mpls traffic-eng router-id interface` | Sets the traffic engineering loopback interface. Example: 
|      | `RP/0/RSP0/CPU0:router(config-isis-af)# mpls traffic-eng router-id Loopback0` | |
| 7    | `segment-routing mpls` | Segment routing is enabled by the following actions: 
|      |   - MPLS forwarding is enabled on all interfaces where IS-IS is active. 
|      |   - All known prefix-SIDs in the forwarding plain are programmed, with the prefix-SIDs advertised by remote routers or learned through local or remote mapping server. 
|      |   - The prefix-SIDs locally configured are advertised. Example: 
|      | `RP/0/RSP0/CPU0:router(config-isis-af)# segment-routing mpls` | |
| 8    | `exit` | Enables traffic engineering functionality on the node. The node advertises the traffic engineering link attributes in IGP which populates the traffic engineering database (TED) on the head-end. The SR-TE head-end requires the TED to calculate and validate the path of the SR-TE policy. Example: 
|      | `exit` | |
| 9    | `mpls traffic-eng` | Enables traffic engineering functionality on the node. The node advertises the traffic engineering link attributes in IGP which populates the traffic engineering database (TED) on the head-end. The SR-TE head-end requires the TED to calculate and validate the path of the SR-TE policy. Example: 
|      | `RP/0/RSP0/CPU0:router(config)# mpls traffic-eng` | |
| 10   | `commit` | |

**What to Do Next**

Configure the prefix SID.

**Configuring a Prefix-SID on the IS-IS Enabled Loopback Interface**

A prefix SID is associated with an IP prefix. The prefix SID is manually configured from the segment routing global block (SRGB) range of labels. The prefix segment steers the traffic along the shortest path to its...
destination. A node SID is a special type of prefix SID that identifies a specific node. It is configured under
the loopback interface with the loopback address of the node as the prefix.

Strict-SPF SIDs are used to forward traffic strictly along the SPF path. Strict-SPF SIDs are not forwarded to
SR-TE tunnels. IS-IS advertises the SR Algorithm sub Type Length Value (TLV) (in the SR Router Capability
SubTLV) to include both algorithm 0 (SPF) and algorithm 1 (Strict-SPF). When the IS-IS area or level is
Strict-SPF TE-capable, Strict-SPF SIDs are used to build the SR-TE Strict-SPF tunnels. Strict-SPF SIDs are
also used to program the backup paths for prefixes, node SIDs, and adjacency SIDs.

The same SRGB is used for both regular SIDs and strict-SPF SIDs.

The prefix SID is globally unique within the segment routing domain.

This task explains how to configure prefix segment identifier (SID) index or absolute value on the IS-IS
enabled Loopback interface.

**Before You Begin**

Ensure that segment routing is enabled on the corresponding address family.

**SUMMARY STEPS**

1. configure
2. router isis instance-id
3. interface Loopback instance
4. address-family { ipv4 | ipv6 } [ unicast ]
5. prefix-sid [strict-spf] {index SID-index | absolute SID-value} [n-flag-clear] [ explicit-null ]
6. commit

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> configure</td>
<td>Enables IS-IS routing for the specified routing instance, and places the router in router configuration mode.</td>
</tr>
</tbody>
</table>

**Step 2**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>router isis instance-id</td>
<td>Enables IS-IS routing for the specified routing instance, and places the router in router configuration mode.</td>
</tr>
</tbody>
</table>

**Example:**

```
RP/0/RSP0/CPU0:router(config)# router isis 1
```

**Step 3**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>interface Loopback instance</td>
<td>Specifies the loopback interface and instance.</td>
</tr>
</tbody>
</table>

**Example:**

```
RP/0/RSP0/CPU0:router(config-isis)# interface Loopback0
```

**Step 4**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>address-family { ipv4</td>
<td>ipv6 } [ unicast ]</td>
</tr>
</tbody>
</table>

**Example:**

```
```
The following is an example for ipv4 address family:

```
RP/0/RSP0/CPU0:router(config-isis-if)#
address-family ipv4 unicast
```

**Step 5**

- **prefix-sid** [strict-spf] {index SID-index} [absolute SID-value] [n-flag-clear] [explicit-null]

**Example:**

```
RP/0/RSP0/CPU0:router(config-isis-if-af)#
prefix-sid index 1001
```

```
RP/0/RSP0/CPU0:router(config-isis-if-af)#
prefix-sid strict-spf index 101
```

```
RP/0/RSP0/CPU0:router(config-isis-if-af)#
prefix-sid absolute 17001
```

**Purpose**

- Configures the prefix-SID index or absolute value for the interface.
- Specify **strict-spf** to configure the prefix-SID to use the SPF path instead of the SR-TE tunnel.
- Specify **index SID-index** for each node to create a prefix SID based on the lower boundary of the SRGB + the index.
- Specify **absolute SID-value** for each node to create a specific prefix SID within the SRGB.

By default, the n-flag is set on the prefix-SID, indicating that it is a node SID. For specific prefix-SID (for example, Anycast prefix-SID), enter the **n-flag-clear** keyword. IS-IS does not set the n flag in the prefix-SID sub Type Length Value (TLV).

To disable penultimate-hop-popping (PHP) and add explicit-Null label, enter **explicit-null** keyword. IS-IS sets the E flag in the prefix-SID sub TLV.

**Note** IS-IS does not advertise separate explicit-NULL or flags for regular SIDs and strict-SPF SIDs. The settings in the regular SID are used if the settings are different.

**Step 6**

- **commit**

Verify the prefix-SID configuration:

```
RP/0/RSP0/CPU0:router# show isis database verbose
```

```
IS-IS 1 (Level-2) Link State Database
LSID: router.00-00 0x0000039b 0xfc27 1079 0/0/0
Area Address: 49.0001
NLPID: 0xcc
NLPID: 0x8e
MT: Standard (IPv4 Unicast)
MT: IPv6 Unicast 0/0/0
Hostname: router
Host Address: 10.0.0.1
IPv6 Address: 10.0.0.1, D:0, S:0
Segment Routing: I:1 V:1, SRGB Base: 16000 Range: 8000
SR Algorithm: 0
Algorithm: 1
<...>
Metric: 0 IP-Extended 10.0.0.1/32
Prefix-SID Index: 1001, Algorithm:0, R:0 N:1 P:0 E:0 V:0 L:0
Prefix-SID Index: 101, Algorithm:1, R:0 N:1 P:0 E:0 V:0 L:0
<...>
```
What to Do Next

Configure the SR-TE policy.

IS-IS Prefix Attributes for Extended IPv4 and IPv6 Reachability

The following sub-TLVs support the advertisement of IPv4 and IPv6 prefix attribute flags and the source router ID of the router that originated a prefix advertisement, as described in RFC 7794.

- Prefix Attribute Flags
- IPv4 and IPv6 Source Router ID

Prefix Attribute Flags

The Prefix Attribute Flag sub-TLV supports the advertisement of attribute flags associated with prefix advertisements. Knowing if an advertised prefix is directly connected to the advertising router helps to determine how labels that are associated with an incoming packet should be processed.

This section describes the behavior of each flag when a prefix advertisement is learned from one level to another.

Note

Prefix attributes are only added when wide metric is used.

Prefix Attribute Flags Sub-TLV Format

```
0 1 2 3 4 5 6 7 ... 
+-------------------... 
|X|R|N| ... 
+-------------------... 
```

Prefix Attribute Flags Sub-TLV Fields

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X (External Prefix Flag)</td>
<td>This flag is set if the prefix has been redistributed from another protocol. The value of the flag is preserved when the prefix is propagated to another level.</td>
</tr>
</tbody>
</table>
| R (Re-advertisement Flag) | This flag is set to 1 by the Level 1-2 router when the prefix is propagated between IS-IS levels (from Level 1 to Level 2, or from Level 2 to Level 1).  
|                           | This flag is set to 0 when the prefix is connected locally to an IS-IS-enabled interface (regardless of the level configured on the interface). |
**IPv4 and IPv6 Source Router ID**

The Source Router ID sub-TLV identifies the source of the prefix advertisement. The IPv4 and IPv6 source router ID is displayed in the output of the `show isis database verbose` command.

The Source Router ID sub-TLV is added when the following conditions are met:

1. The prefix is locally connected.
2. The N-flag is set to 1 (when it's a host prefix and the `n-flag-clear` configuration is not used).
3. The router ID is configured in the corresponding address family.

The source router ID is propagated between levels.

**Table 1: Source Router Sub-TLV Format**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
</table>
| **IPv4 Source Router ID** | Type: 11  
Length: 4  
Value: IPv4 Router ID of the source of the prefix advertisement |
| **IPv6 Source Router ID** | Type: 12  
Length: 16  
Value: IPv6 Router ID of the source of the prefix advertisement |
Configuring Prefix Attribute N-flag-clear

The N-flag is set to 1 when the prefix is a host prefix (/32 for IPV4, /128 for IPv6) that is associated with a loopback address. The advertising router can be configured to not set this flag. This task explains how to clear the N-flag.

**SUMMARY STEPS**

1. configure
2. interface Loopback  instance
3. isis prefix-attributes n-flag-clear [Level-1 | Level-2]
4. commit

**DETAILED STEPS**

<table>
<thead>
<tr>
<th>Command or Action</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong> configure</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong> interface Loopback  instance</td>
<td>Specifies the loopback interface and instance.</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>RP/0/RSP0/CPU0:router(config)# interface Loopback0</td>
<td></td>
</tr>
<tr>
<td><strong>Step 3</strong> isis prefix-attributes n-flag-clear [Level-1</td>
<td>Level-2]</td>
</tr>
<tr>
<td>Example:</td>
<td></td>
</tr>
<tr>
<td>RP/0/RSP0/CPU0:router(config-if)# isis prefix-attributes n-flag-clear</td>
<td></td>
</tr>
<tr>
<td><strong>Step 4</strong> commit</td>
<td></td>
</tr>
</tbody>
</table>

Verify the prefix attribute configuration:

```
RP/0/RSP0/CPU0:router# show isis database verbose
  IS-IS 1 (Level-2) Link State Database
  LSPID  LSP Seq Num  LSP Checksum  LSP Holdtime  ATT/P/OL
  router.00-00  * 0x0000039b  0xfc27  1079  0/0/0
  Area Address: 49.0001
  NLVID: 0xcc
  NLPIID: 0x6e
  MT: Standard (IPv4 Unicast)
  MT: IPv6 Unicast 0/0/0
  Hostname: router
  IP Address: 10.0.0.1
  IPv6 Address: 2001:0db8:1234::a00:0001
  Router Cap: 10.0.0.1, D:0, S:0
  Segment Routing: I:1 V:1, SRGB Base: 16000 Range: 8000
  SR Algorithm:
  Algorithm: 0
  Algorithm: 1
```

...
IS-IS Multi-Domain Prefix SID and Domain Stitching: Example

IS-IS Multi-Domain Prefix SID and Domain Stitching allows you to configure multiple IS-IS instances on the same loopback interface for domain border nodes. You specify a loopback interface and prefix SID under multiple IS-IS instances to make the prefix and prefix SID reachable in different domains.

This example uses the following topology. Node 5 and 9 are border nodes between two IS-IS domains (Domain1 and Domain2). Node 10 is configured as the IOS XR Traffic Controller (XTC) (see Configure IOS XR Traffic Controller (XTC)).

Figure 1: Multi-Domain Topology

Configure IS-IS Multi-Domain Prefix SID

Specify a loopback interface and prefix SID under multiple IS-IS instances on each border node:

Example: Border Node 5
router isis Domain1
  interface Loopback0
    address-family ipv4 unicast
      prefix-sid absolute 16005
  router isis Domain2
interface Loopback0
  address-family ipv4 unicast
  prefix-sid absolute 16005

Example: Border Node 9
router isis Domain1
  interface Loopback0
  address-family ipv4 unicast
  prefix-sid absolute 16009

router isis Domain2
  interface Loopback0
  address-family ipv4 unicast
  prefix-sid absolute 16009

Border nodes 5 and 9 each run two IS-IS instances (Domain1 and Domain2) and advertise their Loopback0 prefix and prefix SID in both domains.

Nodes in both domains can reach the border nodes by using the same prefix and prefix SID. For example, Node 3 and Node 22 can reach Node 5 using prefix SID 16005.

Configure Common Router ID

On each border node, configure a common TE router ID under each IS-IS instance:

Example: Border Node 5
router isis Domain1
  address-family ipv4 unicast
  mpls traffic-eng level-2-only
  mpls traffic-eng router-id Loopback0

router isis Domain2
  address-family ipv4 unicast
  mpls traffic-eng level-2-only
  mpls traffic-eng router-id Loopback0

Example: Border Node 9
router isis Domain1
  address-family ipv4 unicast
  mpls traffic-eng level-2-only
  mpls traffic-eng router-id Loopback0

router isis Domain2
  address-family ipv4 unicast
  mpls traffic-eng level-2-only
  mpls traffic-eng router-id Loopback0

Distribute IS-IS Link-State Data

Configure BGP Link-state (BGP-LS) on Node 13 and Node 14 to report their local domain to Node 10:

Example: Node 13
router isis Domain1
  distribute bgp-is level 2

Example: Node 14
router isis Domain2
  distribute bgp-is level 2
Nodes 13 and 14 each reports its local domain in BGP-LS to Node 10. Node 10 identifies the border nodes (Nodes 5 and 9) by their common advertised TE router ID, then combines (stitches) the domains on these border nodes for end-to-end path computations.
Distribute IS-IS Link-State Data